

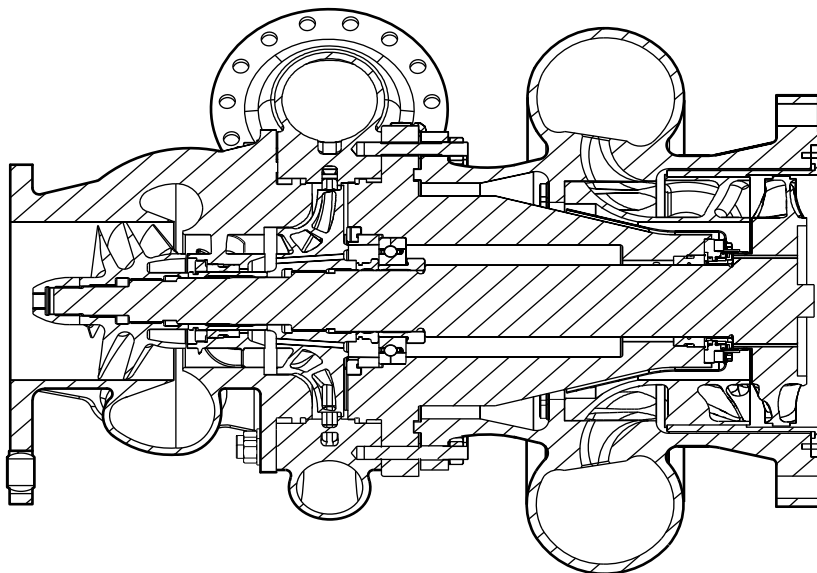
## Revolutionary Reusable Technology Turbopump

Mary E. Koelbl/EP32  
205-544-7073  
E-mail: mary.koelbl@msfc.nasa.gov

The revolutionary reusable technology turbopump (RRTT) is a NASA/MSFC technology program intended to demonstrate a substantial reduction in the time and cost to produce reusable turbomachinery. A reusable liquid oxygen turbopump sized for a full-flow staged combustion cycle engine at a thrust of 400,000 lbf was selected as the demonstration turbopump. The goals of the program were: (1) to define the design, perform the required analyses, fabricate the hardware, and assemble the turbopump within 18 months; and (2) to limit the recurring fabrication and first unit cost to less than \$600,000. This is a factor of three reduction in schedule and a factor of five reduction in cost from traditional rocket engine turbomachinery. Rocketdyne was selected as the contractor for the program which began in September 1995.

To achieve the aggressive schedule goal, a document called a product and process plan of action (PPPOA) was jointly written between Rocketdyne and NASA/MSFC. It combined an engineering design and analysis plan, a manufacturing plan, a quality plan, and a product validation plan into a single document which was approved by both Rocketdyne and NASA prior to initiation of the design phase. The PPPOA also defined, in detail, all of the ground rules, assumptions, and the required level of analysis for each part.

A product development team (PDT) was established with members from all of the appropriate disciplines at Rocketdyne, NASA/MSFC, and the appropriate vendors. Each team member was an active participant in the design phase to ensure the schedule and cost goals could be achieved while still meeting the design requirements. The manufacturing and inspection process



**FIGURE 29.—Revolutionary Reusable Technology Turbopump (RRTT) cross section.**

development was begun concurrently with the design process to minimize schedule and cost risk. With this approach, the process development is an essential element of the design itself. In addition, the three-dimensional computer aided design (CAD) models were electronically linked with stress and thermal analysis packages to enable rapid design generation and iterations. The vendors were part of the electronic drawing transfer as well. The three-dimensional models were used to produce rapid prototype casting patterns.

This process was significantly cheaper and quicker than fabricating conventional hard tooling to produce wax patterns. The electronic drawings were also downloaded to the vendor numerically controlled (NC) machines.

A cross section of the turbopump is shown in figure 29. The turbopump consists of a high-pressure liquid oxygen pump driven by a single stage turbine using an oxygen-rich working fluid. The fluid requirements for the turbopump are shown in table 2. The

**TABLE 2.—RRTT fluid conditions.**

	Pump	Turbine
Fluid	Lox	Oxygen-Rich Steam (O <sub>2</sub> + H <sub>2</sub> O)
Inlet Pressure (psia)	200	5,034
Inlet Temperature (deg R)	169	1,145
Discharge Pressure (psia)	6,404	3,315
Flow Rate (lbm/sec)	922	860

RRTT is not man-rated flight hardware but is typical of future reusable turbomachinery. The life requirements for the RRTT were derived from the number of tests necessary to characterize the turbopump and to validate the processes used during the design and fabrication.

Considerable effort was spent during the design and analysis phase on the turbine design. The design was challenging due to the requirements of an oxygen-rich turbine. Materials were carefully chosen for oxygen compatibility and extensive material testing was performed to validate the material selection.

The RRTT hardware is currently in fabrication. To date the program is only one month behind and 6 percent over the cost goal. The assembly of the turbopump is currently planned to be complete by April 1997.

**Sponsor:** Long-term, high-payoff project

**Biographical Sketch:** Mary E. Koelbl has been a design engineer in the Turbomachinery Branch of Propulsion Laboratory at Marshall Space Flight Center for 10 years. She works on SSME fuel turbomachinery as well as turbomachinery technology programs. 